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ROTHAMSTED  
RESEARCH

## Rothamsted Experimental Station - Guide to the Experimental Plots 1906

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### The Park - Grass Land Mown for Hay Every Year

#### Rothamsted Research

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THE PARK

*Grass Land Mown for Hay every Year*

The experiments upon grass at Rothamsted began in 1856, about 7 acres of the park close to the house being set aside for the purpose. The land has been in grass as long as any recorded history of it exists, for some centuries at least. It is not known that seed has ever been sown, and at the beginning of the experiments the herbage on all the plots was apparently uniform.

The plots, of which there are twenty in all, vary somewhat in size, which lies between one-half and one-eighth of an acre. Up to 1874 inclusive the grass was only cut once, the aftermath being fed off by sheep. Since that time there has been no grazing, and the plots are generally cut twice in the year. The grass is made into hay in the usual way, and the whole produce of each plot is then weighed.

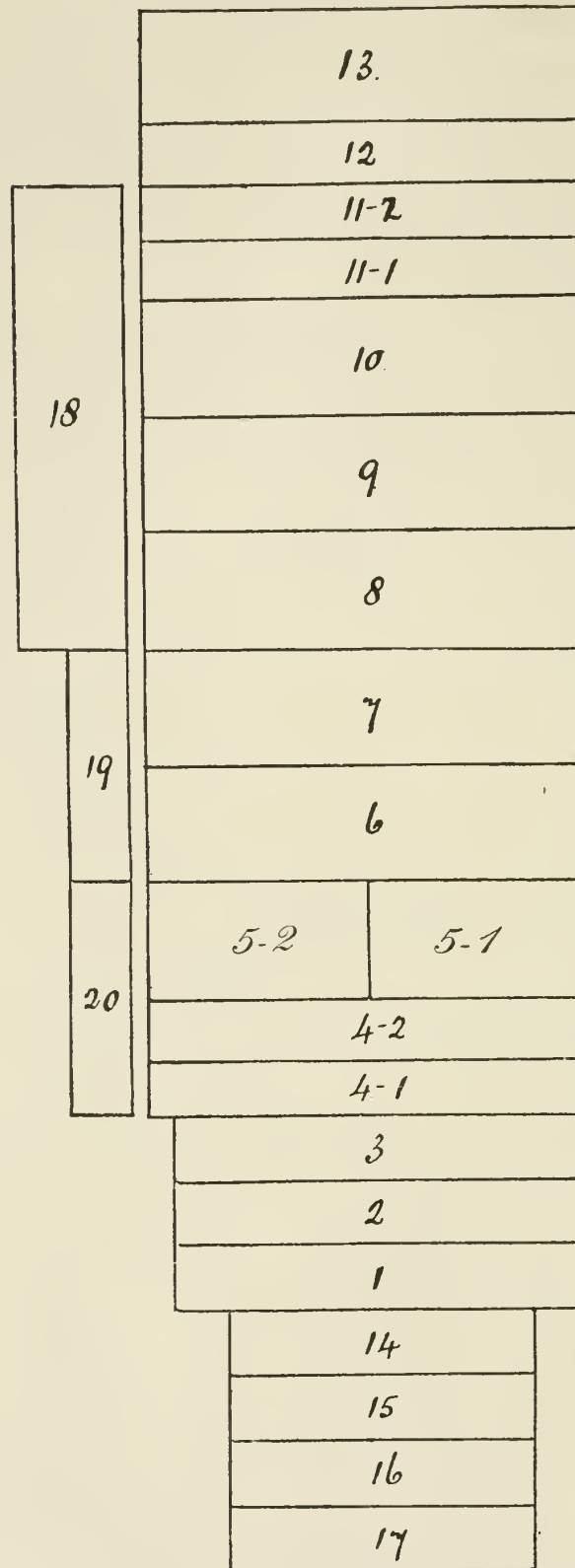
TABLE X.—*Manuring of the Permanent Grass Plots per acre per annum, 1856 and since.*

Plot.	Abbreviated Description of Manures.	Nitrogenous Manures.		Mineral Manures.				
		Ammonium-salts.	Nitrate of Soda.	Super-phosphate.	Sulphate of Potash.	Sulphate of Soda.	Sulphate of Magnesia.	Silicate of Soda.
		Lb.	Lb.	Cwt.	Lb.	Lb.	Lb.	Lb.
3 12	} Unmanured every year . . . . .	...	...	...	...	...	...	...
2 1	Unmanured; following Dung first 8 years . Ammonium-salts alone; with Dung also first 8 years . . . . .	...	...	...	...	...	...	...
4-1 8 7	Superphosphate of Lime . . . . . Mineral Manure without Potash . . . . . Complete Mineral Manure . . . . .	...	...	3.5 3.5 3.5	... ... 500	... *250 100	... 100 100	... ... ...
6 15	As Plot 7; Ammonium-salts alone first 13 years . . . . . As Plot 7; Nitrate Soda alone first 18 years	...	...	3.5 3.5	500 500	100 100	100 100	... ...
5 17	Ammonium-salts alone (to 1897) . . . . . Nitrate of Soda alone . . . . .	400 ...	... 275	... ...	... ...	... ...	... ...	... ...
4-2 10 9 13 11-1 11-2	Superphosphate and Ammonium-salts . Mineral Manure (without Potash) and Am- monium-salts . . . . . Complete Mineral Manure and Ammonium- salts . . . . . As Plot 9, and Chaffed Wheat Straw also to 1897 . . . . . Complete Mineral Manure and Ammonium- salts . . . . . As Plot 11-1, and Silicate of Soda . . . . .	400 400 400 400 600 600	... ... ... ... ... ...	3.5 3.5 3.5 3.5	... ... 500 500	... *250 100 100	... 100 100 100	... ... ... ... ... 400
16 14	Complete Mineral Manure and Nitrate Soda Complete Mineral Manure and Nitrate Soda	... ...	275 550	3.5 3.5	500 500	100 100	100 100	... ...

\* Reduced in 1905 to 100 lb.

C.—Plan of the Plots in the Park on which Experiments have been made on the Mixed Herbage of Permanent Grass Land.

1856 and onwards.



Total area under Experiment, about 7 acres.

Area of Plots { 1, 2, 3, 4-1, 4-2, 5-1, 5-2, 11-1, 11-2, and 12, each  $\frac{1}{4}$  acre.  
 6, 7, 8, 9, 10, 13, and 18, each  $\frac{1}{2}$  acre.  
 14, 15, 16, and 17, each  $\frac{1}{3}$  acre.  
 19 and 20, each  $\frac{1}{5}$  acre.

GRASS FOR HAY

TABLE XI.—*Produce of Hay per acre. Average over the period of 47 years (1856-1902), the 10 years (1893-1902), and the individual year 1905. Rothamsted. Total of first, and second crops (if any).*

Plot.	Abbreviated Description of Manures.	Averages over		Season 1905.
		47 years (1856-1902).	10 years (1893-1902).	
3 12	} Unmanured every year . . . . . {	Cwt. 21·9	Cwt. 15·9	Cwt. 19·4
		24·5	18·5	24·7
2	Unmanured; following Farmyard Dung for first 8 years . . . . .	27·9*	17·4	23·2
1	Ammonium-salts alone (=43 lb. N.); with Farmyard Dung for first 8 years . . . . .	35·4†	24·9	26·3
4-1	Superphosphate of Lime . . . . .	23·3§	17·8	22·3
8	Mineral Manure without Potash . . . . .	28·1	21·6	30·3
7	Complete Mineral Manure . . . . .	38·8	36·5	52·9
6	Complete Mineral Manure as Plot 7; following Ammonium-salts alone first 13 years . . . . .	37·4‡	36·0	46·1
15	Complete Mineral Manure as Plot 7; following Nitrate of Soda alone first 18 years . . . . .	37·0	40·8	51·9
5	Ammonium-salts alone=86 lb. Nitrogen . . . . .	(26·1)**	...	...
17	Nitrate of Soda alone=43 lb. Nitrogen . . . . .	35·3¶	30·6	39·7
4-2	Superphosphate and Ammonium-salts=86 lb. N. . . . .	35·5§	28·3	31·5
10	Mineral Manure (without Potash), and Ammonium-salts=86 lb. N. . . . .	49·3	38·1	37·3
9	Complete Mineral Manure and Ammonium-salts =86 lb. N. . . . .	54·1	46·8	48·6
13	As Plot 9, and Chaffed Wheat Straw also to 1897 inclusive . . . . .	62·5**	...	...
11-1	Complete Mineral Manure, and Ammonium-salts =129 lb. N. . . . .	65·5	64·6	59·0
11-2	As Plot 11-1, and Silicate of Soda . . . . .	72·0	68·0	74·5
16	Complete Mineral Manure and Nitrate Soda =43 lb. N. . . . .	48·0¶	42·4	52·3
14	Complete Mineral Manure and Nitrate Soda =86 lb. N. . . . .	59·3¶	53·4	57·6

\* After the change. Before the change, 42·9 cwt. § 44 years only (1859-1902).  
 † " " 49·5 cwt. ¶ 45 years only (1858-1902).  
 ‡ " " 30·6 cwt. \*\* 42 years (1856-1897).  
 || " " 35·4 cwt.

*The Unmanured Plots*

Two of the plots have remained without manure during the whole of the experiment. They are situated near the extremities of the field, and show a slight but constant difference in crop. Taking the average of the whole period, these unmanured plots have produced rather more than a ton of hay per acre per annum. If we compare the successive ten-year returns, there is no sign of approaching exhaustion or great falling-off in crop from year to year. The impoverishment of these unmanured plots is more to be seen in the character of the herbage than in the gross weight of produce. Weeds of all descriptions occupy the land, and the relative proportion they bear to the grasses and clovers has increased from year to

year. A fair proportion of clovers, both red and white, is found on these plots, but the weeds, which amount to 26 per cent. taking the average over the whole period, have of late years constituted nearly one-half of the herbage. The most prominent species among the grasses are the

TABLE XII.—Percentages of Gramineous, Leguminous, and Miscellaneous Herbage. Average of 47 years (1856-1902, and 1902 separately). Rothamsted. First crops.

Plot.	Manures.	Averages over 47 years (1856-1902).			Season 1902.		
		Gram- ineæ.	Legu- minosæ.	Miscel- laneæ.	Gram- ineæ.	Legu- minosæ.	Miscel- laneæ.
		Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
3	} Unmanured every year . {	64·8	8·9	26·3	34·3	7·5	58·2
12		64·9	9·0	26·1	38·1	16·1	45·8
2	Unmanured; following Farm- yard Dung for first 8 years .	75·5	4·3	20·2	24·4	5·7	69·9
1	Ammonium-salts alone (= 43 lb. N.); with Farmyard Dung for first 8 years . . . . .	87·8	0·7	11·5	77·6	1·4	21·0
4-1	Superphosphate of Lime . . . . .	68·0	5·8	26·2	54·4	15·4	30·2
8	Mineral Manure without Pot- ash* . . . . .	70·6	6·8	22·6	28·8	22·1	49·1
7	Complete Mineral Manure . . . . .	62·0	23·8	14·2	20·3	55·3	24·4
6	Complete Mineral Manure as Plot 7; following Ammo- nium-salts alone first 13 yrs.	...	...	...	18·4	61·0	20·6
15	Complete Mineral Manure as Plot 7; following Nitrate of Soda alone first 18 years . . . . .	...	...	...	26·2	63·1	10·7
5	Ammonium-salts alone = 86 lb. N. . . . .	80·5	0·4	19·1	...	...	...
17	Nitrate of Soda alone = 43 lb. N.	71·0	1·3	27·7	43·8	3·4	52·9
4-2	Superphosphate and Ammo- nium-salts = 86 lb. N. . . . .	88·2	0·1	11·7	91·5	(0·01)	8·5
10	Mineral Manure (without Pot- ash),* and Ammonium-salts = 86 lb. N. . . . .	90·7	0·1	9·2	97·6	(0·01)	2·4
9	Complete Mineral Manure and Ammonium-salts = 86 lb. N.	88·7	0·4	10·9	91·2	1·3	7·5
13	As Plot 9, and Chaffed Wheat Straw also to 1897 inclusive	92·3	0·3	7·4	98·1	0·6	1·3
11-1	Complete Mineral Manure and Ammonium-salts = 129 lb. N.	95·8	0·1	4·1	99·2	0	0·8
11-2	As 11-1, and Silicate of Soda .	97·5	0	2·5	99·5	0	0·5
16	Complete Mineral Manure and Nitrate Soda = 43 lb. N. . . . .	82·9	5·4	11·7	61·7	12·8	25·5
14	Complete Mineral Manure and Nitrate Soda = 86 lb. N. . . . .	90·6	1·3	8·1	88·8	3·7	7·5

\* Including Potash first 6 years.

Quaking Grass, so generally taken as a sign of poor land, which constituted 20 per cent. of the whole herbage in 1903, and Sheep's Fescue; among leguminous plants the Bird's Foot Trefoil; and Burnet, Hawkbit, and Black Knapweed among the weeds.

*Use of Nitrogenous Manures alone*

Three of the plots—17, 5, and 1—show the effect of the long-continued use of nitrogenous without any mineral manures, Plot 5 has been receiving 86 lbs. of nitrogen as ammonium-salts, Plot 17 half the quantity of nitrogen in the shape of nitrate of soda, and Plot 1 the same half quantity of nitrogen as ammonium-salts, though on this plot dung was applied in each of the first eight years of the experiment. It is very evident when a nitrogenous manure is used alone for grass, nitrate of soda is far more effective than the ammonium-salts; *e.g.*, on Plot 17 it has given an average crop of 35 cwt. against 26 cwt. produced by double the quantity of nitrogen in ammonium-salts on Plot 5.

*Mineral Manures used alone*

On three of the plots no nitrogenous manures have been applied since the beginning of the experiments. On Plot 7 a complete mineral manure,

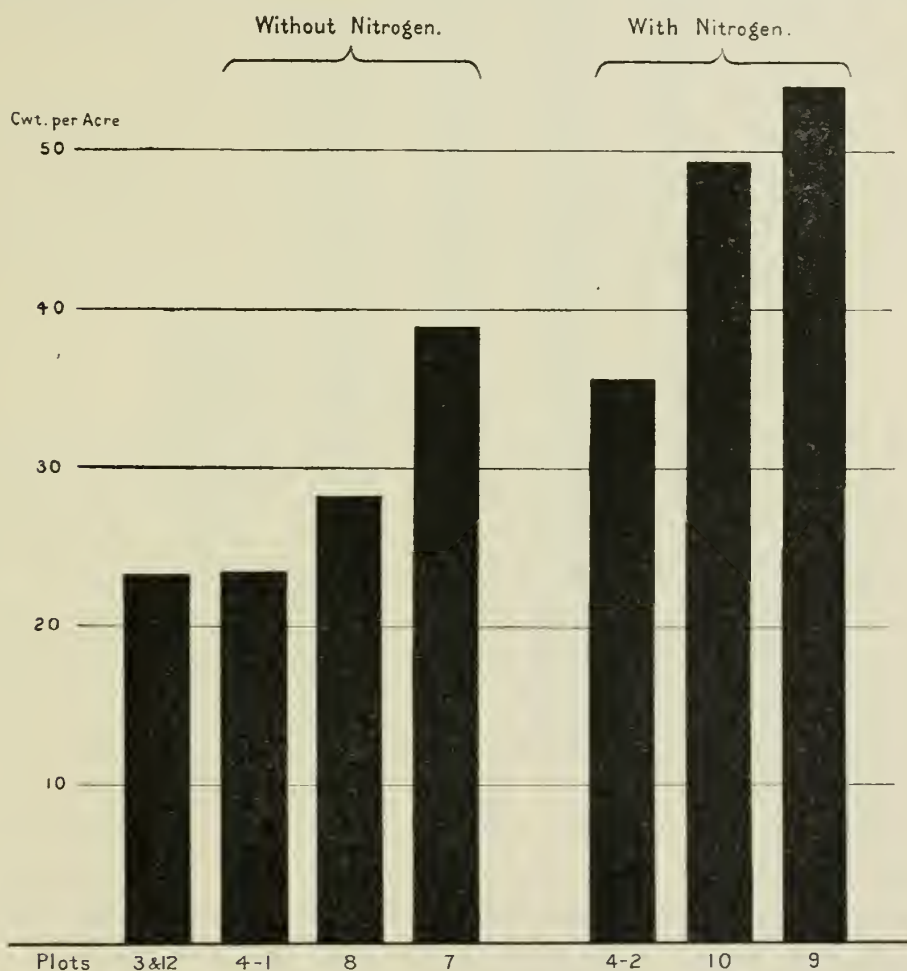


FIG. 6.—Effect of the various Ash constituents with and without Nitrogen on the produce of Hay per acre. Average over 47 years (1856-1902).

- |                                  |   |
|----------------------------------|---|
| Plots 3 and 12. Unmanured.       | Plot 4-2. Super. and Amm.-salts = 86 lb. N.                   |
| Plot 4-1. Superphosphate.        | Plot 10. Minerals (without Potash) and Amm.-salts = 86 lb. N. |
| Plot 8. Minerals with Potash.    | Plot 9. Complete Mineral Manure and Amm.-salts = 86 lb. N.    |
| Plot 7. Complete Mineral Manure. |   |

supplying phosphoric acid, potash, magnesia, and soda, is used ; Plot 8 has received the same application, but without potash, since 1861, while Plot 4-1 receives superphosphate only. With the complete minerals a fair crop is grown, averaging over  $1\frac{1}{2}$  ton of hay for the first cut alone. The reason that the crop on this plot is maintained, although no nitrogen is supplied in the manure, lies in the free growth of leguminous plants. It will be seen that, taking the average over the whole period, the leguminous plants form 24 per cent. of the herbage, and the proportion has increased from year to year.

The omission of potash on Plot 8 has caused a very striking difference both in the crop and in the character of the herbage. The average crop has been about one-quarter less over the whole period, and shows a progressive decline in fertility, until at the present time it is little more than half that of Plot 7. The poor results on this plot, as compared with Plot 7, must be put down to its poverty in leguminous herbage, the development of which seems to depend on a free supply of potash. Of late years the proportion of leguminous plants on this plot has amounted to about one-half of that found on Plot 7, the grasses are about the same, the difference being made up by an increased amount of weed.

Plot 4-1, which each year has received superphosphate only, now presents a very impoverished appearance, and is giving no more crop than the unmanured plots. Indeed, the aspect of this plot, where the most abundant grass is Quaking Grass, and where weeds, chiefly Hawkbit, Burnet, and Plantain, are unusually prominent, would seem to indicate that the land is more exhausted here than on the unmanured plot.

#### *Complete Manures—Nitrogen and Minerals*

Among the plots which receive both nitrogenous and mineral manures, Plot 9, with a complete mineral manure and ammonium-salts should be compared with Plot 14, which is exactly similar except that the nitrogen is applied in the form of nitrate of soda, and again with Plot 16, where only half the amount of nitrogen is applied, but again as nitrate of soda. The nitrate of soda gives the heavier yield, the herbage is also more diversified, and there is not the total absence of leguminous plants which marks the plots receiving ammonium-salts. Two characteristic plants, Soft Brome Grass and Beaked Parsley, are found only on the plots receiving nitrate of soda, the corresponding umbelliferous plant where ammonium-salts are used being the Earth Nut (*Conopodium*).

On Plot 11 the same mineral manures are applied with an extra amount of ammonium-salts, so that the nitrogenous manuring is excessive. As a result the vegetation consists entirely of tufts of three coarse grasses—Meadow Foxtail, Yorkshire Fog, and Tall Oat Grass. The soil has also become sour and unhealthy, with the result that the plant is dying in patches, except on the upper portion of the plot where lime has been applied, and on the half numbered 11-2 where the silicate of soda is used.

The effect of omitting potash from the complete manure is seen on Plot 10, and again on Plot 4-2, where superphosphate and ammonium-salts only are applied. It is noticeable that the grass on these plots is weak in the straw and liable to fungoid attacks.

GRASS FOR HAY

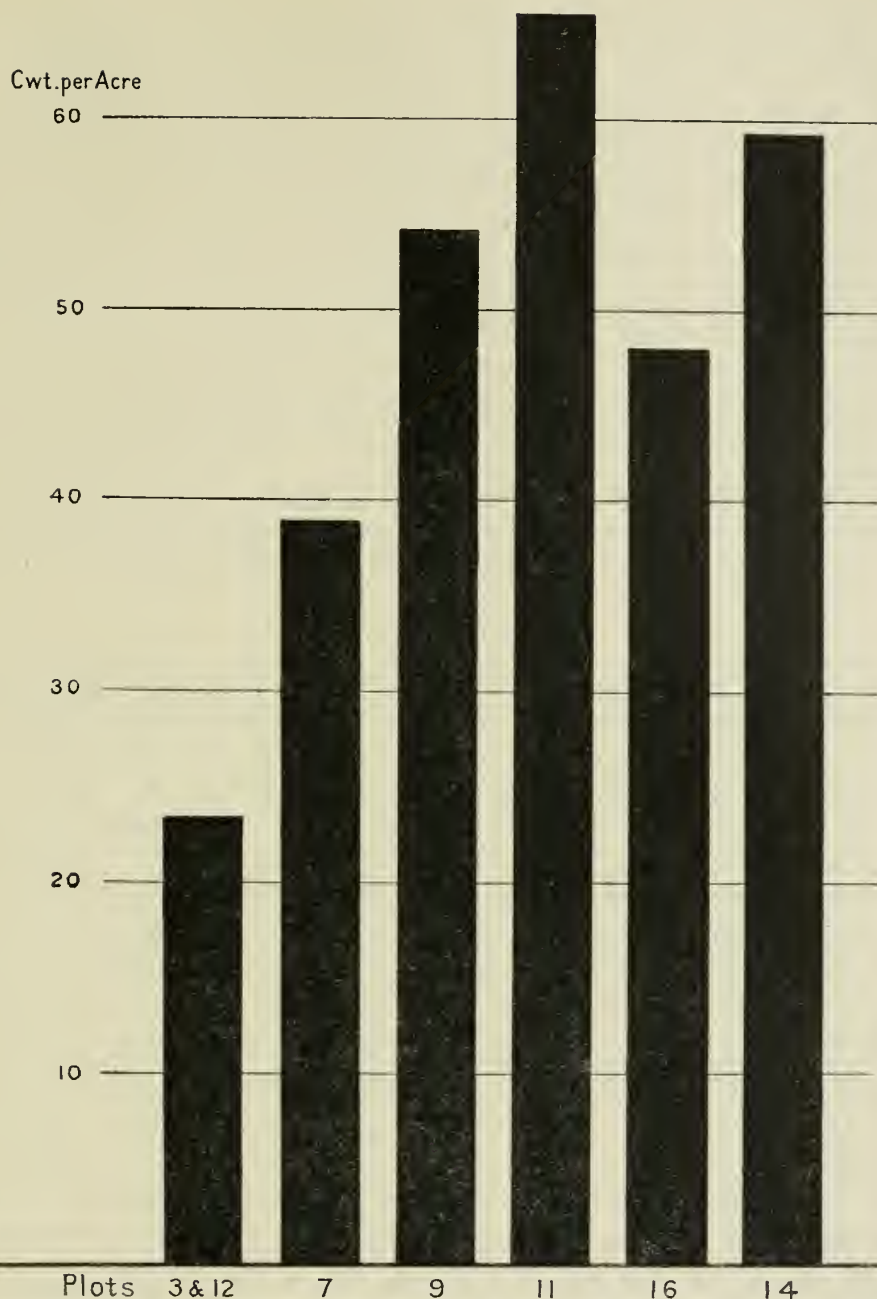


FIG. 7.—Effect of Nitrogenous Manures on the produce of Hay per acre. Average over 47 years (1856-1902).

- Plot 3 and 12. Unmanured.
- Plot 7. Complete Mineral Manure, no Nitrogen.
- Plot 9. Do. and Amm.-salts = 86 lb. N.
- Plot 11. Do. do. = 129 lb. N.
- Plot 16. Do. and Nitrate of Soda = 43 lb. N.
- Plot 14. Do. do. = 86 lb. N.

*Changes in the Herbage following changes in Manuring*

Plot 6 was up to 1868 manured with ammonium-salts alone, like the adjoining Plot 5: the ammonium-salts were then replaced by a complete